Aug. 26, 1952 W. A. DEPP 2,608,674

MULTICATHODE GLOW DISCHARGE DEVICE

Filed Feb. 9, 1951 2 SHEETS--SHEET 1

FIG. 1

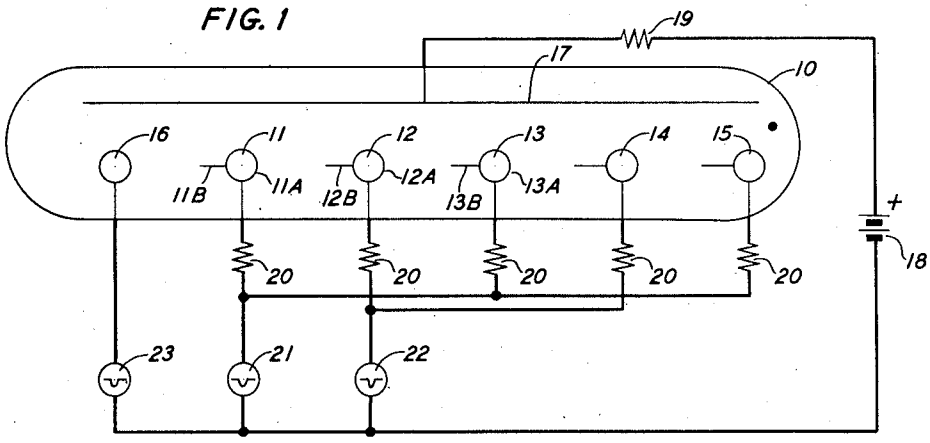

FIG. 2

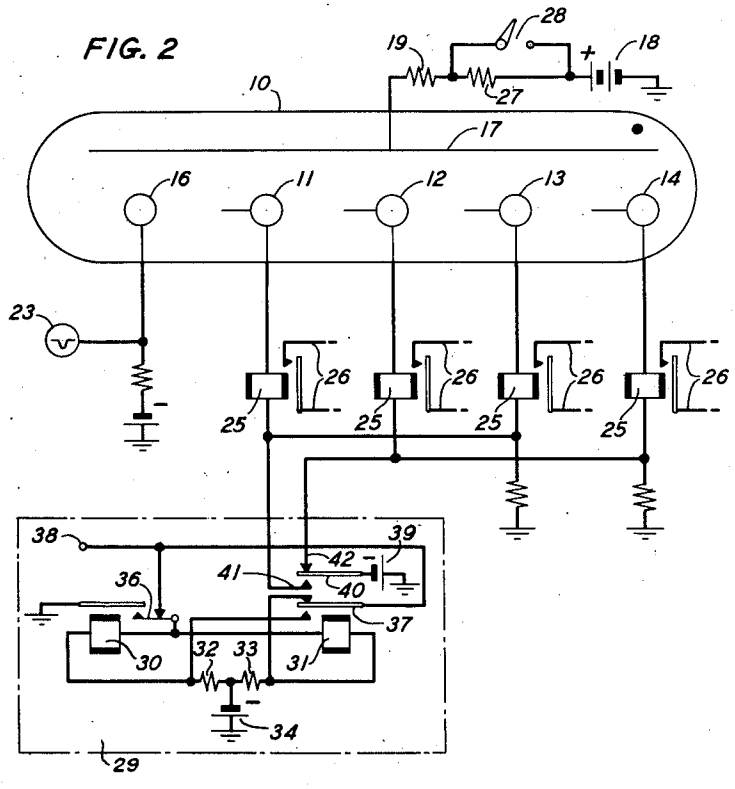

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FIG. 3

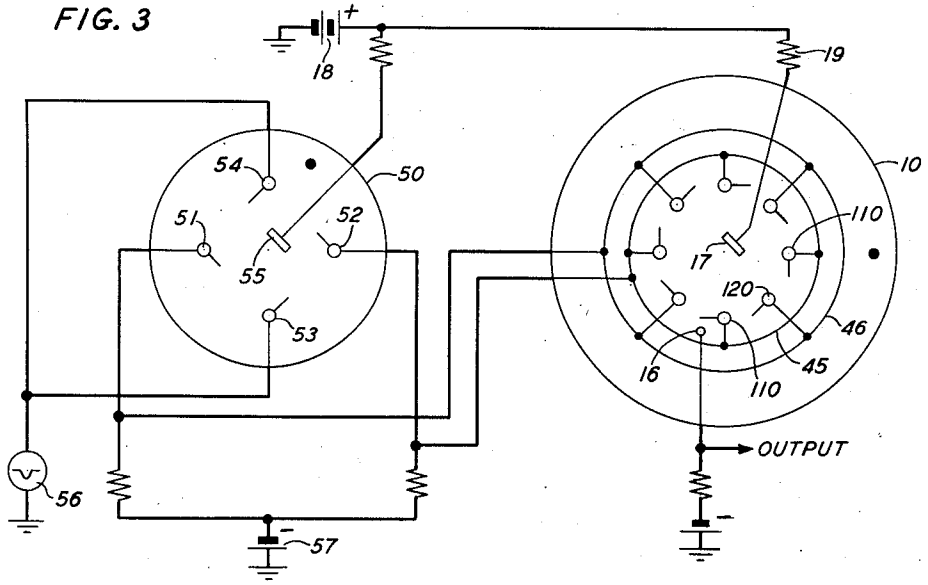
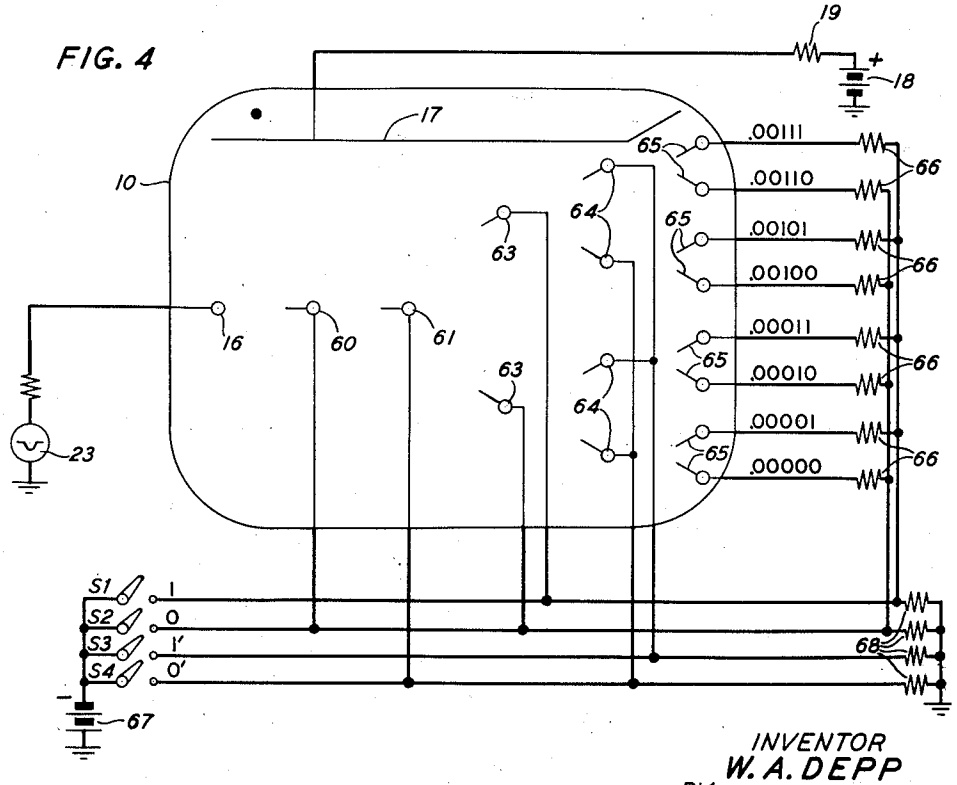


FIG. 4



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MULTICATHODE GLOW DISCHARGE DEVICE

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Application February 9, 1951, Serial No. 210,183

5 Claims. (Cl. 315—169)

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This invention relates to gaseous discharge devices and more particularly to multielectrode glow discharge devices of the general type disclosed in the application Serial No. 101,322, filed June 25, 1949 of M. A. Townsend, now Patent 2,575,370, granted November 20, 1951.

Devices of this type comprise an array of glow cathodes connected electrically in two groups with the cathodes of the two groups in alternate relation, and an anode opposite the cathodes and biased with respect thereto at a positive potential sufficient to sustain a discharge across any cathode-anode gap. The cathodes of one group may have individual load circuits connected thereto.

In the operation of the device, a discharge is initiated at one of the cathodes in the one group mentioned and the discharge is stepped along the array by applying signal pulses to the cathodes of the other group to drive these cathodes negative with respect to those of the first group. The discharge is shifted two cathodes for each applied pulse. Thus, the number of cathodes requisite for any desired number of output circuits is double this number of circuits.

One general object of this invention is to simplify multicathode gaseous discharge devices of the general type above described. More specifically, one object of this invention is to reduce the number of cathodes necessary to provide a given number of rest positions for the discharge or, stated in another way, to increase the number of individual output circuits which can be controlled by a device having a given number of cathodes.

In accordance with one feature of this invention, in a discharge device of the general construction above described, means are provided for applying pulses alternately to the two groups of cathodes to drive each group negative with respect to the other, whereby to shift the discharge from one cathode to the next in response to one pulse. Each cathode defines a rest position for the discharge so that the number of output circuits which can be utilized or controlled is equal to the number of cathodes.

The invention and the above noted and other features thereof will be understood more clearly and fully from the following detailed description with reference to the accompanying drawing in which:

Fig. 1 is a diagram illustrating the principal components and the association thereof in a gaseous discharge device constructed in accordance with this invention;

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Fig. 2 illustrates one embodiment of this invention wherein individual relay controlled output circuits are coupled to the several cathodes, and shows one manner in which the signal pulses may be applied to the two groups of cathodes;

Fig. 3 illustrates another embodiment of this invention wherein the cathodes are disposed in circular array, and shows another way in which the signal pulses for stepping may be provided; and

Fig. 4 is a diagram illustrating another embodiment of this invention, specifically the application of the invention to a binary translator or counter of the general type disclosed in the application Serial No. 168,227, filed June 15, 1950 of M. A. Townsend.

Referring now to the drawing, the discharge device illustrated in Fig. 1 comprises an enclosing vessel 10 having therein an ionizable atmosphere, such as a rare gas or mixture of rare gases. Mounted in linear array and equally spaced within the vessel 10 are a plurality of glow cathodes 11 to 15 inclusive. Each of these cathodes, which may be of the constructions disclosed in the application Serial No. 101,322 referred to hereinabove, comprises two portions of different efficiencies as glow discharge sustaining elements the portions of higher efficiency being designated in the drawing by the letter A and the lower efficiency portions by the letter B. As shown in Fig. 1, the cathodes are arranged with the lower efficiency portion B of each toward and in juxtaposition to the high efficiency portion of the next preceding cathode, i. e. the cathode to the left in the figure. At one end of the row of cathodes is a normal or reset cathode 16. Opposite all of the cathodes is an anode 17.

The anode 17 is biased positive with respect to all of the cathodes by a source 18, through resistor 19, at a potential sufficient to sustain a discharge between any cathode and the anode. The cathodes 11 to 15 inclusive, are connected together in two groups with the cathodes of the two groups in alternate relation each cathode having in circuit therewith a resistor 20. Sources 21 and 22 of negative input pulses are connected to the two groups of cathodes respectively as shown. Another source 23 of negative pulses is connected to the normal or reset cathode 16.

Certain principles involved in the operation of the device will be understood from the following considerations. Assume that a discharge is sustaining at one of the cathodes, say the cathode 12. Because of the cathode construction, the discharge concentrates upon the higher efficiency

portion thereof, the portion 12A in the case noted. The discharge can be shifted to an adjacent cathode by driving such adjacent cathode sufficiently more negative, relative to the anode, than the cathode at which the discharge sustains. If two cathodes adjacent the one at which a discharge is sustaining are so driven negative simultaneously, the discharge will transfer to the one of these adjacent cathodes having the lower transfer voltage. As described in detail in the application Serial No. 101,322 referred to hereinabove, the cathode construction and arrangement as in the device disclosed in Fig. 1 hereof provides a preference mechanism whereby stepping of the discharge to a prescribed one of two such adjacent cathodes is effected. Specifically, for the case here under consideration, that is with the discharge sustaining at cathode 12, if the cathodes 11 and 13 are driven negative simultaneously, the discharge will shift or step to the cathode 13, the transfer voltage from cathode 12 to cathode 13 being much smaller than that from cathode 12 to cathode 11 because of the preference mechanism above referred to.

The discharge will stay upon cathode 13 so long as this cathode remains sufficiently negative with respect to the adjacent cathodes 12 and 14, particularly the latter. This condition may be realized by maintaining an appropriate bias upon the cathode 13 for the duration of the period for which it is desired that the discharge remain at cathode 13. It can be realized also by utilizing negative pulses to effect the stepping and by making the resistor 20 such that with the discharge sustaining at any cathode, and even after cessation of the pulse, the voltage drop across the resistor 20 associated with that cathode is less than the transfer voltage between that cathode and the next succeeding one. For example, if the discharge is stepped from cathode 12 to cathode 13 by a negative pulse applied to cathode 13, the discharge will remain at cathode 13 after cessation of the pulse provided that the resistor 20 associated with the cathode 13 is such that the voltage drop thereacross is less than the transfer voltage requisite to step or shift the discharge to cathode 14.

The discharge, sustaining at any of the cathodes 11 to 15, can be transferred to the normal or reset cathode 16 by application of a large negative pulse or bias to the cathode 16.

It will be noted that when the discharge sustains at any of the cathodes 11 to 15, a voltage appears across the respective resistor 20. Such voltage may be utilized to control a respective load or output circuit.

The device illustrated in Fig. 1 may be operated in one way as follows: A negative pulse is applied to the normal or reset cathode 16 from the source 23 to cause breakdown of the anode 17—cathode 16 gap and, thus, establish a discharge thereacross. Then negative pulses are applied alternately to the cathodes 11, 13 and 15 and the cathodes 12 and 14 from the sources 21 and 22 respectively. In response to application of the first pulse from the source 21, the discharge transfers from cathode 16 to the cathode 11, concentrates upon the portion 11A and remains at this cathode even after the pulse terminates. In response to the first pulse from source 22, the discharge transfers from cathode 11 to cathode 12 and sustains at the latter. In like manner, in response to successive pulses, applied alternately, from the sources 21 and 22, the discharge steps or transfers from cathode 12 to cathode 13, then from the latter to cathode 14 and finally from cathode 14 to cathode 15. A strong pulse applied to normal or reset cathode 16 will return the discharge to cathode 16.

It will be noted that the discharge sustains at any cathode to which it is stepped even after the pulse which resulted in the stepping of the discharge thereto terminates. Thus, each of the cathodes 11 to 15 is a rest cathode and utilizable for control of an individual load circuit associated therewith, as through the respective resistor 20. Hence, it will be appreciated that the number of output or load circuits which can be controlled is equal to the number of cathodes, omitting the normal or reset cathode 16. Of course, any such circuit may be controlled by application of a prescribed number of pulses to the device. For example, three pulses, two from the source 21 and one from the source 22 will step the discharge from cathode 16 to cathode 13 and the discharge will sustain at this cathode after termination of the third pulse.

It will be understood, of course, that although the device illustrated on Fig. 1 and described hereinabove includes five rest cathodes, a greater or lesser number of cathodes may be employed.

Fig. 2 illustrates one manner in which the stepping pulses may be applied to the two groups of cathodes, and also in which the load or output circuits may be controlled. As shown, each of the cathodes 11 to 14 has in circuit therewith a respective relay 25 the contacts 26 of which are to be connected in a load circuit. The anode 17 is biased through a pair of resistors 19 and 27, the resistor 27 being arranged to be short circuited by a switch 28.

Negative signals are applied alternately to the two groups of cathodes 11, 13 and 12, 14 by operation of the two relay switching system 29. The latter, which is of conventional configuration, comprises a pair of relays 30 and 31 connected as shown with resistors 32 and 33 and to the source 34 and having their armatures 36 and 37 respectively connected to a ground pulse terminal 38. Briefly, this system operates as follows: When a ground pulse is applied to terminal 38, relay 30 operates and upon termination of this pulse relay 31 operates. Operation of the relay 31 causes application of a negative potential from source 39 over armature 40 and contact 41 to the cathodes 11 and 13. When a second ground pulse is applied to terminal 38, relay 30 releases and at the end of this pulse relay 31 releases. Release of relay 31 results in application of a negative potential from source 39 over armature 40 and contact 42 to cathodes 12 and 14. This cycle of operations is repeated for successive ground pulses applied to the terminal 38. Thus, negative signals are applied alternately to the two groups of cathodes and the discharge is stepped from cathode to cathode in the same manner as described heretofore with reference to Fig. 1.

The discharge current during the stepping of the discharge may be limited by the resistors 19 and 27 to a value below that necessary to cause operation of the relays 25. When the discharge has been stepped to a desired cathode, the switch 28 is closed whereby the discharge current rises to a value sufficient to operate the relay associated with that cathode.

The stepping of the discharge by the application of pulses alternately to the two groups of cathodes may be effected also as illustrated in Fig. 3. As there shown, the device wherein the discharge is stepped comprises a plurality of

cathodes 110 and 120, which may be of the same construction as those in the device of Fig. 1, mounted in circular array and connected electrically in two groups by bus wires 45 and 46. The device includes also the normal or reset cathode 16 and the anode 17.

Stepping pulses are applied alternately to the two groups of cathodes by pulsing of a flip-flop gaseous discharge device 50. The latter includes four glow cathodes 51 to 54, which may be of the same construction as the cathodes 110 and 120, and an anode 55 opposite the four cathodes. Each of the cathodes 51 and 52 is connected to a respective group of the cathodes 110 and 120 as shown. The cathodes 53 and 54 are connected together to a source 56 of pulses for driving these cathodes negative with respect to the cathodes 51 and 52. The latter normally are biased negative relative to the cathodes 53 and 54 by the source 57.

The operation of the device illustrated in Fig. 3 will be understood from the following: A discharge is initiated in the stepping device by applying a negative pulse to the normal or reset cathode 16, as in the other embodiments of this invention described hereinabove. Similarly, a discharge is initiated in the pulsing device 50 by applying a negative pulse to one of the cathodes 51 or 52. Assume that discharges are sustaining at the cathode 51 and the cathode 110 nearest reset cathode 16. When a negative pulse from the source 56 is applied to the cathodes 53 and 54, the discharge shifts first from cathode 51 to cathode 54 and then upon cessation of the pulse to cathode 52. As a result, the potential of cathodes 110 will change from negative to positive with respect to ground and the potential of cathodes 120 changes from positive to negative with respect to ground. Consequently, the discharge in the stepping device transfers from the cathode 110 at which it was initially to the next adjacent cathode 120 in the counter-clockwise direction and will rest at the latter cathode. In like manner, each successive pulse from the source 56 causes the discharge in the stepping device to step one cathode in the counter-clockwise direction.

An output pulse may be obtained by way of the normal or reset cathode 16 for each completion of transfer of the discharge around the circular array of the cathodes in the stepping device. Alternatively, individual load circuits may be associated with the cathodes 110 and 120 as in the devices illustrated in Figs. 1 and 2.

The invention may be utilized to particular advantage also in binary translators of the general type disclosed in the application Serial No. 168,227 referred to hereinabove. One illustrative embodiment, shown in Fig. 4, comprises the gas-filled enclosing vessel 10, a normal or reset cathode 16 and an anode 17. Mounted in order are preceding cathodes 60 and 61 and three rows of cathodes 63, 64 and 65, the number of cathodes 64 being double the number of cathodes 63 and half the number of cathodes 65. Each of the cathodes, similarly to those in the devices shown in Figs. 1, 2 and 3 has two portions of different efficiencies as glow discharge elements and has its lower efficiency portion toward and in juxtaposition to the higher efficiency portion of a preceding cathode. It will be noted that both the cathodes 63 have their lower efficiency portion in juxtaposition to the cathode 61 and their higher efficiency portion in juxtaposition to the lower efficiency portions of a respective pair of the cathodes 64. Similarly, each of the cathodes

64 is ccooperatively associated with a respective pair of the cathodes 65. The latter constitute the output electrodes of the device and have individual load circuits, represented by the resistors 66, coupled thereto.

Because of the construction and relation of the cathodes, it will be appreciated that a discharge sustaining at either of the cathodes 63 may be stepped to either of the respective pair of cathodes 64 and that a discharge sustaining at any of the cathodes 64 may be transferred to either of the respective pair of cathodes 65. Thus, a discharge sustaining at cathode 61 may be stepped to any one of the cathodes 65 by application of an appropriate group of pulses to the cathodes.

The pulse grouping may be in accordance with a binary code and involve permutations of 0 and 1 pulses. For the eight output electrode devices illustrated in Fig. 4, groups of five pulses are utilized. The permutation of pulses requisite to bring the discharge to each of the cathodes 65 is indicated opposite these cathodes in the drawing. The pulses, which are negative, may be applied from a source 67 over switches S–1, S–2, S–3 and S–4 connected to bus bars 1, 0, 1′ and 0′ respectively, which are grounded, as shown, through resistors 68, and connected to the several cathodes as shown in Fig. 4. It will be noted that in the device of Fig. 4, as in those illustrated in Figs. 1, 2 and 3, the cathodes are electrically interconnected in groups so that along a row, alternate cathodes are tied together and a discharge can be stepped along such row by applying negative pulses alternately to alternate cathodes. For example, a discharge can be stepped from the normal cathode 16 to the lowermost cathode 65 by alternately closing the switches S–2 and S–4, thereby to step the discharge from cathode 16 to cathode 60, then to cathode 61, to lower cathode 63, to lowermost cathode 64 and thence to the lowermost cathode 65.

As another example, the discharge may be stepped from cathode 16 to the output cathode 65 corresponding to code group 00101 in the following manner:

Apply pulse to cathode 16 thereby initiating a discharge thereat;

Close S_2 thereby stepping the discharge to cathode 60;

Close S_4 and open S_2, thereby stepping the discharge to cathode 61;

Close S_1 and open S_2, thereby stepping the discharge to upper cathode 63;

Close S_4 and open S_1, thereby stepping the discharge to next to top cathode 64;

Close S_1 and open S_4, thereby stepping the discharge to cathode 65 (00101);

Open S_1. The discharge remains on cathode 65 (00101).

When a discharge obtains at any of the cathodes 65, a potential appears across the resistor 66 associated with that cathode and this may be utilized as the output signal. This potential is positive with respect to ground and thus is readily distinguishable from the negative potentials which may appear across the resistors during the stepping in response to the pulses applied to the buses 0, 0′, 1 and 1′. Although some potential may appear across other of the resistors 66 these may be made negligible for practical purposes by making the resistors 68 small in comparison to the resistors 66.

Although specific embodiments of the inven-

tion have been shown and described, it will be understood that they are but illustrative and that various modifications may be made therein without departing from the scope and spirit of this invention.

What is claimed is:

1. A gaseous discharge device comprising an array of two groups of cathodes, the cathodes of the two groups being in alternate relation and said cathodes being constructed and arranged to provide a discharge transfer preference from cathode to cathode in one direction along the array, an anode opposite said cathodes, means biasing said anode positive with respect to said cathodes at a potential sufficient to sustain a discharge between said anode and any of said cathodes, means for establishing a discharge at one of said cathodes, and means for stepping the discharge from cathode to cathode along the array comprising means for applying alternately to said two groups signals of polarity to drive said groups individually more negative relative to said anode.

2. A gaseous discharge device comprising an array of two groups of cathodes, the cathodes of the two groups being in alternate relation, each of said cathodes having two portions of different efficiencies as glow discharge elements and said cathodes being disposed with the lower efficiency portion of each in juxtaposition to the higher efficiency portion of the next preceding cathode in the array, an anode oppposite said cathodes, means biasing said anode positive with respect to said cathodes at a potential sufficient to sustain a discharge between said anode and any of said cathodes, means for establishing a discharge at one of said cathodes, and means for stepping the discharge from cathode to cathode along the array comprising means for applying negative signal pulses alternately to the two groups of cathodes.

3. A gaseous discharge device in accordance with claim 2 wherein said pulse applying means comprises a pair of pulse sources each connected between said anode and a respective one of said groups, the device comprising also a resistor individual to and in circuit with each of said cathodes.

4. A gaseous discharge device in accordance with claim 2 wherein said pulse applying means comprises a signal source and means for connecting said source alternately to the two groups of cathodes.

5. A gaseous discharge device comprising a plurality of glow cathodes mounted in an array composed of one cathode followed by a series of rows with the number of cathodes in successive rows increasing by a fractor of two and each cathode in each but the last row being in cooperative relation with a respective pair of cathodes in the next succeeding row, there being two cathodes in the first row and said one cathode being in juxtaposition thereto, an anode opposite said cathodes, said cathodes defining a plurality of individual paths each extending from said one cathode to a respective cathode in said last row, an anode opposite said cathodes, means biasing said anode relative to said cathodes at a potential sufficient to sustain a discharge between said anode and any cathode, means for establishing a discharge at said one cathode, and means for stepping said discharge selectively along any one of said paths comprising means for applying negative pulses in succession to the successive cathodes defining the one path.

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No references cited.